E-05

Structure-property Relationship of Self-assembled Multiferroic $CoFe_2O_4$-$PbTiO_3$ Nanocomposites

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Self-assembled multiferroic $CoFe_2O_4$ (CFO)-$PbTiO_3$ (PTO) nanocomposites have been fabricated on a $SrTiO_3$ (001) substrate by metalorganic chemical vapor deposition. Ferrimagnetic CFO filaments were observed to form in a ferroelectric PTO matrix due to the competition of surface and interfacial energies as verified by energy-dispersive x-ray spectroscopy using the FEI Tecnai F20ST at the Electron Microscopy Center. Traditional cross-sectional transmission electron microscopy shows the filaments are of different shapes, suggesting they may be branched. Scanning transmission electron microscopy (STEM) tomography was performed to better resolve the "Y" shaped CFO filament in one sample. The lower atomic weight of CFO has a lower STEM high-angle angular dark field contrast than the PTO matrix, allowing for a tomographic STEM reconstruction. The shape anisotropy from the high aspect ratio of CFO filaments (20 nm in diameter vs. 300 nm in length) realigns the direction of the easy axis of magnetization in the filaments to the out-of-plane [001] direction as opposed to the in-plane [100] direction favored in blanket CFO thin films. However, the close packed nature of the CFO filaments may hinder the volume change of the PTO matrix resulting from an applied electric field, which makes it difficult to probe the ferroelectric properties of the heterostructures at the resolution of piezoresponse force microscopy.